6.—ECOLOGICAL SUCCESSION OBSERVED DURING REGENERATION OF TRIODIA PUNGENS R.Br. AFTER BURNING.

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Certain investigations, into the sheep carrying capacity of the spinifex country of the north-west of Western Australia, are being carried out by officers of the Institute of Agriculture of the University of Western Australia, at Warralong Station, about sixty miles east-south-east of Port Hedland. The name spinifex is used locally for various species of *Triodia* R.Br. In the course of a taxonomic study of this genus the writer visited the country between Port Hedland and Marble Bar during the months May, June and July, 1941. Some weeks were spent at Warralong. An area of 400 acres, on this property, is being used for certain feeding experiments. The spinifex cover has been removed by burning and the plots therefore provide an excellent area for a study of regeneration. Two quadrats (20 x 20 links) were mapped in the experimental area and two (50 x 50 links) in adjacent country which provided examples of more advanced regrowth.

The climate is semi-arid with high summer temperatures. Rain may fall at any time between December and March. The falls may be spread over some months or there may be heavy storms (willy-willies) when the average for the year may be exceeded during a twenty-four hour period. The yearly aggregates are, however, not notably variable and the climate may be described as one in which dry summers are common, but prolonged droughts rare. In 1941 a dry summer was followed, in early March, by a violent storm which caused record floods in many of the rivers.

The Warralong experimental plots are situated on the granitic plain to the south of the De Grey River. Except for an occasional ridge of stony hills due to intrusive rocks the general landscape is flat or very gently undulating. The soil is a light sandy loam, reddish in colour (Teakle, 1938).

The vegetation has been described as semi-desert savannah (Teakle l.c.). Spinifex (*Triodia* spp.) is the dominant genus. *T. pungens* R.Br. is the most important species and is frequently the only perennial grass present. Small trees and shrubs are present; their relative density varies and appears to be dependent on some soil factor which is, as yet, unrecognised.

T. pungens is the only species of the genus with real pastoral value. It is a coarse, tussock-forming, resinous grass very variable in its growth habit. At the Warralong plots the general form is a pyramidal tussock varying in size up to two metres in diameter and about the same in height.

The use of fire to improve pasture is, of course, practised in many parts of the world. Old fibrous and unpalatable material is burnt and young regrowth is more easily reached by the grazing animal. In burning spinifex it has been assumed, and indeed widely claimed, that the fire burns the tussock back to a central butt from which young shoots develop. While this is admittedly true in some places, the writer's observations showed that it is by no means always so. Over a wide area fire causes the complete destruction of the plants and regeneration takes place by means of seedling establishment.

Observations showed that along the coastal zone, from Port Hedland to the northern end of the 80-Mile Beach, burning left the tussocks with a viable butt whose regrowth was available to the grazing animal within a few months. However, through the inland country along the De Grey, Shaw and Coongan Rivers up to Marble Bar the tussocks are completely destroyed and it is at least a year before regrowth is available to the sheep. Under such conditions the risk of soil erosion is great. Fortunately the *Triodia* tussocks are fairly widely spaced (Fig. 4) and it is difficult to keep a running fire going. Thus only small patches from two or three tussocks up to about an acre are burnt in each place. The spacing of the ground cover has probably played an important role in protecting the vegetation from the consequences of biotic activities during the seventy years of pastoral occupation.

The general custom is to burn during the mustering period in April and June when the men, riding the paddocks, drop lighted matches at random. Sporadic burning is carried out at any time during the year.

It is evident that, if the tussocks are completely destroyed in May or June, the ground will lie bare until the following January or March when the summer rains bring about seedling germination. It was hoped that a study of the progress of regeneration might show whether any undesirable changes are likely to occur as a result of the burning process. That the vegetation may be altered will be shown in the discussion on succession. The alteration is a result of a combination of factors of which fire is one.

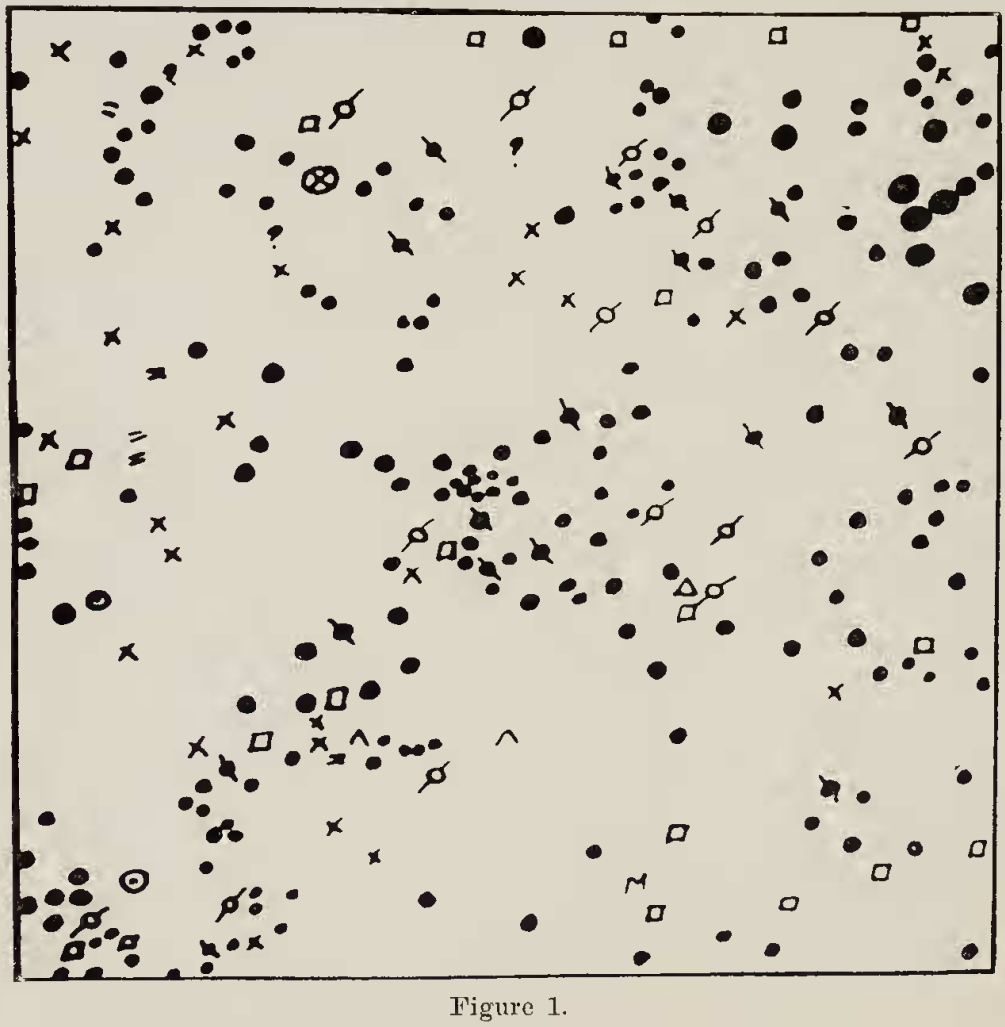

Figure 1.

QUADRATS.

Figures 1 and 2 (20 x 20 links = 4 x 4 metres), represent the primary stage in regeneration. The *Triodia* seedlings are associated with numerous annual species. The areas mapped were on the Warralong experimental plots and the original cover was burnt off in December, 1940. Rain fell in March (willy-willy) and in April and May (light falls). The quadrats were mapped in June. It is evident that germination took place at more than one stage. The seedlings varied from 2-6 cm. in height.

The sandy loam had a scanty cover of drift sand, formerly associated with tussocks. This drift sand was disturbed by the March floods. It is probable that many seeds, imbedded in the sand, were washed away. Whether this had much effect on the relative abundance of the various annual species cannot be ascertained from one season's observations. The sand drifts do, however, explain the grouping of seedlings which is evident on the maps.

In Figure 3 (50 x 50 links = 10 x 10 metres) the patch of ground represented was about a hundred yards from the experimental plots. The quadrat was surveyed in June. At this stage of regrowth there was fierce competition between the *Triodia* tussocks and ephemeral growth was meagre. In one corner an adult tussock had survived. Across another there is a patch of primary regrowth which suggests that it was burnt in the previous season.

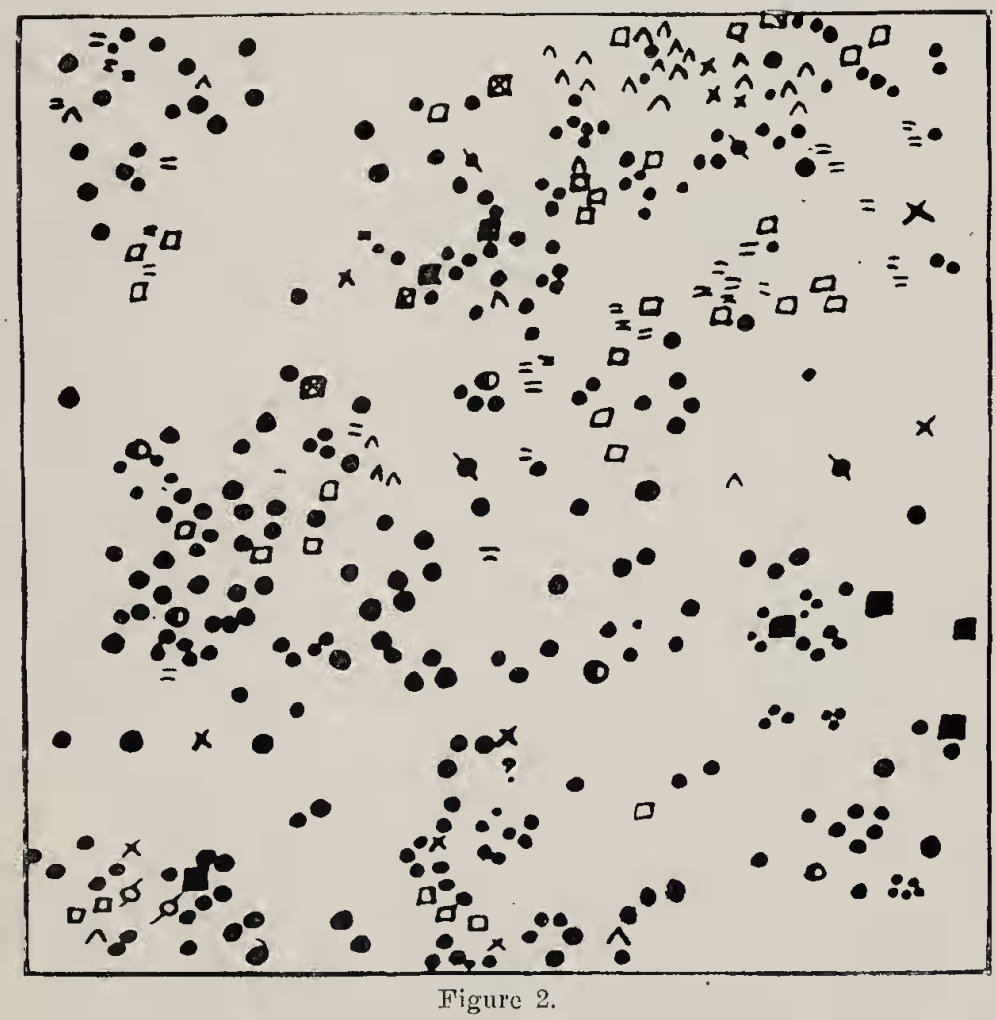

Figure 2.

It was at least two and possibly three years since the plants on the rest of the quadrat had germinated. They were about 30-40 cm. high.

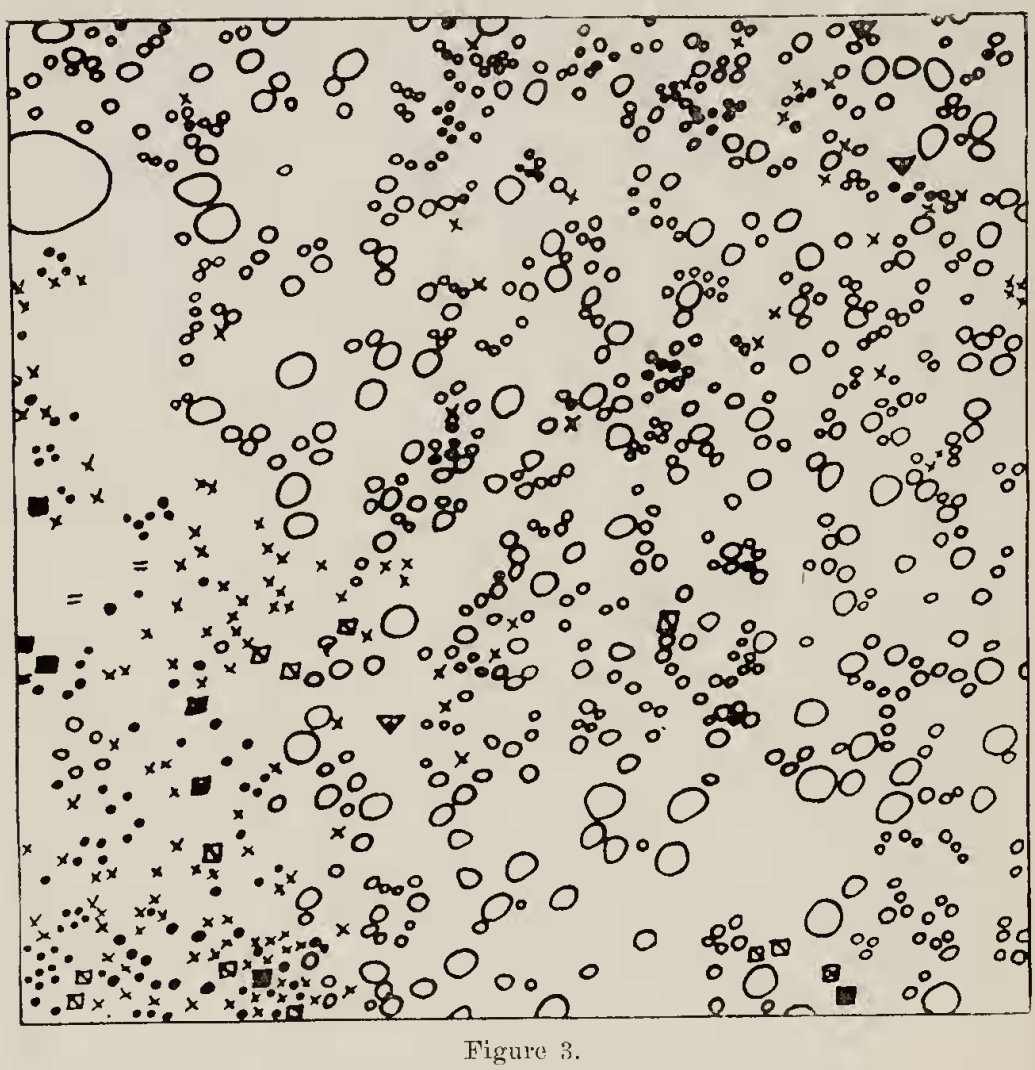

Figure 3.

In Fignre 4 (50 x 50 links = 10 x 10 metres) the adult tussock stage is represented. *Triodia pungens* had established a closed eommunity and ephemeral growth was negligible.

The quadrat was surveyed on ground about two hundred yards from the experimental plots. All ephemeral growth was dead when the mapping was done in June. Observations snggest that it was at least five years sinee this pateh of grounnd had been burnt and probably much longer. The plants were about 70-100 em. high.

Conntry surromnding the quadrat earried occasional plants of blood-wood (*Eucalyptus dichromophloia*), kangi (*Acacia pyrifolia*) and gema (*Carissa lanceolata*).

REGENERATION.

The germination of *Triodia* seeds is rapid after rain has sufficiently moistened the soil. The proeess seems to be related to soil moisture and not to any particnlar period of the year. However only those plants which germinate early in the year form a root system extensive enongh to support it during the drought eonditions of the ensuing summer months.

Figure 4.

The *Triodia* seedlings are soon followed by small annuals such as *Mollugo molluginis, Euphorbia australis, Portulaca oleracea, Bulbostylis barbata, Eriachne pulchella, Aristida arenaria, Sporobolus australasicus, Eragrostis Dielsii* and *Ichnanthus australiensis.* Amongst perennials which are present at this stage the most important is *Cassia notabilis.* This species is an indicator of recent burning (within two or three years). As the plants are destroyed by termites they do not appear in older patches of spinifex. It is possible that fire improves the germination rate of this species. Other perennials which occur as occasional plants are *Solanum diversifolium, Sida platycalyx, Corchorus elachocarpus, Hybanthus enneaspermus, Eragrostis eriopoda, Eriachne obtusa, Chrysopogon pallidus* and *Neurachne Clementii.*

The areas chosen for the first two quadrats represented good regeneration. Other ground nearby varied from heavier regrowth to none at all. Regrowth appeared to be related to the water content of the soil. Areas burnt before or shortly after the March floods carried good regrowth. Those burnt later showed fewer and fewer seedlings as burning continued through the months. Those burnt in May showed no regrowth at all. There was no rain during June or July.

Apart from regeneration on burnt areas, regrowth was also to be seen on claypans wherever sand drifts formed. As a result, these bare areas

usually had an irregular formation due to patches of regrowth, in various stages of regeneration, here and there on their surface.

During the summer months following the first period of seedling development soil moisture continues to play a leading part and presumably becomes a severely limiting factor. Those seedlings whose roots have not penetrated more than the top layers of soil soon die. It is a feature of young *Triodia* seedlings that they have the most feeble attachment to the soil. It is not unusual to see a tussock 10 or 15 cm. high and about the same in diameter with only a single root holding it to the soil.

The ephemeral growth dies off very early, the majority having finished seeding by September which marks the commencement of the hot weather. The perennials, including *T. pungens,* pass into a practically dormant state.

In the second season the young tussocks compete not only with each other, but also with another crop of annuals resulting from the summer rains. These include *Polanisia icosandra, Aristida arenaria, Dactylotaenium radulans, Mollugo molluginis, Indigofera viscosa* and other species present during the first season.

By the third season the competition between the tussocks has become the dominant feature and annuals play a minor role. (Fig. 3).

As the tussocks become older many die out. Others coalesce to form compound groups. Owing to the formation of adventitious roots at many nodes, both on the ground and throughout the clump of culms, the plants after the first year, become attached to the soil at many points within their circumference. The plants mapped in Figs. 3 and 4 all exhibited one or both of these traits.

ECOLOGICAL SUCCESSION.

The areas denuded of plant cover as a result of burning represent "secondary" bare areas, ecologically speaking, as opposed to "primary" bare areas such as those left by landslips or earthquakes.

In this case it is not essential that plants immigrate from other areas to form a new population since the soil may already contain the elements necessary for regeneration. This is so in the spinifex country since regrowth comes from seeds in the soil.

The regenerative sere may be divided into the following stages:—(i) primary stage with annuals and *Triodia* seedlings in open competition. This covers the period from germination until the rains of the following summer; (ii) secondary stage lasting more than one season, during which period the *Triodia* seedlings assume a dominant role and eliminate the annuals from the association; (iii) adult tussock stage where the *Triodia* plants have formed a closed community in which there is very little or no ephemeral growth; (iv) climax association where small trees and shrubs (which are present in a young state in (ii) and (iii)) such as *Eucalyptus dichromophloia, Acacia pyrifolia, Atalaya hemiglauca, Dolichandrone heterophylla, Hakea lorea* (as examples of the former); and *Carissa lanceolata, Cassia venusta, Cassia oligophylla* and *Acacia translucens* (as examples of the latter); are associated with adult tussocks.

The effect of man and his grazing animals on the association appears, so far, to have been very slight in comparison with the effect on native vegetation in other parts of the State. Nevertheless there are places, both on

Warralong and on adjoining properties, where major changes in the vegetation can be recognised. The *Triodia* on these areas has been destroyed and replaced with an *Eragrostis eripoda*-dominant association. This disturbance of the normal sequence is not merely a retrogressive change in the succession and it seems best to define it as a *disclimax*. That the disclimax is a "permanent" change is indicated by the fact that in one place the coarse woolly bases so characteristic of *Eragrostis eripoda* averaged 20 cm. in diameter. According to report this represented more than fifteen years of growth. The basic causes of the change seem to be burning followed by prolonged and heavy stocking. Whether burning was a primary cause in all cases could not be proved. In this *Eragrostis* association seedlings of *Triodia pungens* were absent and it is doubtful if they could establish themselves against the fierce competition. That the country formerly carried *Triodia pungens* is known from report and from the existence of isolated tussocks of this species among the *Eragrostis plants*. Other plants present, both ephemeral and perennial, were the same as those in a normal *Triodia pungens*-association.

In one area, on the adjoining property of Eginbah, there were indications that the *Eragrostis eripoda*-association was being removed in its turn by the grazing animal. The result was a growth of annuals in which *Mollugo molluginis*, *Aristida arenaria*, *A. hygrometrica* and *Polanisia icosandra* were the most important species. This represents a return to the condition seen in the early stages of the sere on a bare area.

SUMMARY.

Burning of *Triodia pungens* results in either the destruction of the tussock with regeneration from seedlings or a viable butt remains which sprouts again almost immediately.

In the coastal region, between Port Hedland and the northern end of the 80-Mile Beach, a viable butt is left, but inland along the Shaw, Coongan, and De Grey Rivers the tussocks are usually destroyed.

Quadrats showing stages in regeneration after burning are figured and discussed. These were mapped in or near the experimental plots at Warralong Station.

A sere is defined. The climax is one in which small trees and shrubs are associated with the dominant *Triodia pungens*. Ephemeral growth is scanty in the mature stage.

A permanent change in the vegetation, due to fire and the grazing animals, is described.

ACKNOWLEDGMENTS.

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REFERENCE.

1938, Teakle, L. J. H.: A. Regional Classification of the Soils of Western Australia. *Jour. Roy. Soc., W.A.*, Vol. 24, 1937-38.

KEY TO SYMBOLS USED IN FIGURES.

Triodia pungens seedling	
„ „ tussock	
Sporobolus australasicus	
Eriachne pulchella	
Ichnanthus australiensis	
Eragrostis eriopoda	
Bulbostylis barbata	
Mollugo molluginis	
Portulaca oleracea	
Polanisia icosandra	
Cassia notabilis	
Clianthus Dampieri	
Euphorbia australis	
Goodenia	
„	
Miscellaneous	